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(54) IMPROVEMENTS IN OR RELATING TO STRAIGHTENING MACHINES

(71) We, NIPPON STEEL CORPORATION, a Japanese Company, of No. 6-3, 2-chome, Ote-machi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the straightening of metal sections, and especially (but not exclusively) to the straightening of rolled steel sections. The invention particularly relates to a method of and apparatus for straightening such sections.

Steel sections — unlike plates — usually have complicated cross-sectional shapes, and after hot rolling and cooling it is usual for sections to have considerable but undesirable bends. Sectional steels are used widely, but especially in the ship-building and construction industries, and straightness and uniform cross-sectional shape are important properties. With the advance of automatic processing machines (such as numerically controlled machines) in recent years, it is most important that excellent straightness be obtained.

Known forms of straightening machines usually comprise a plurality of rollers the axes of which are horizontal and the rollers being disposed to define a vertically wavy (or zig-zag) path therebetween. When a section is passed along the path, it is bent repeatedly, thereby removing the residual bends following cooling after hot rolling. However, it is found that when such machines are used on unsymmetrical sections (such as unequal angles), considerable buckling can take place on the longer legs of the sections, resulting in a most unsatisfactory end product.

According to one aspect of this invention, there is provided a method of straightening a section comprising constraining a section to be straightened to move along a path curved in a substantially horizontal plane (as defined herein), and rolling at least a part of

the section simultaneously to reduce the thickness of that part.

The section will normally be constrained to follow the curved path by means of constraining rollers suitably disposed, the rolling being effected by pressure rollers mounted opposed to the constraining rollers such that the section passes therebetween.

In a preferred form of the method of this invention, the path is generally straight, but is curved alternately to either side of the generally straight line of the path. Thus, the constraining rollers are conveniently disposed with their centre lines alternately to one and to the other side of the generally straight line of the path.

It will be appreciated that by "horizontal plane", as used herein, is meant that the section follows a path curved in a plane parallel to the axes of the constraining and pressure rollers, which plane will usually be truly horizontal; however, in an abnormal construction of a machine for effecting the method of this invention these rollers could be mounted with their axes vertical, in which case the section would of course be constrained to follow a path curved in a truly vertical plane.

At the same time as constraining the section to follow a curved path in a substantially horizontal plane, it is preferred for the section also to follow a curved path in a generally vertical plane — thus that the section is simultaneously bent in two mutually perpendicular directions both generally normal to the line of the said path. For a method employing constraining rollers, the path curved in a vertical plane is conveniently wavy (or zig-zag) about a generally straight mean, the section being repeatedly bent in alternate senses in a plane normal to the axes of all the rollers as the section is moved along the path, as in the case of the known forms of straightening machines.

Although it is possible to reduce the thickness of the whole of a section whilst straightening it according to the method of this in-

vention, it is preferred for a part only to be reduced. When straightening a section having two distinguishable parts (for instance, an unequal angle), it is preferred for the minor part to be reduced — thus for the short leg only in the case of an unequal angle.

According to a further aspect of this invention, there is provided a roller straightening machine for performing the method described above, comprising means including one constraining roller defining a path curved in a substantially horizontal plane (as defined herein), along which path a section is constrained to move whilst being straightened and as least one pressure roller opposed to the said one constraining roller and on the opposite side of the path to the constraining roller, the peripheries of the constraining and pressure rollers being shaped so as to correspond to the shape of the section to be straightened, the pressure roller being mounted for movement towards and away from the constraining roller such that a section being moved along the path can be reduced in thickness by the rollers, and both rollers being movable parallel to their axes to adjust the curvature of the said path.

It will be appreciated that by displacing the pair of constraining and pressure rollers in a direction parallel to their axes (i.e. usually horizontally), the section being straightened will be constrained to follow a path curved in a substantially horizontal plane (as described herein). Furthermore, by displacing the pair of constraining and pressure rollers parallel to the line connecting their axes (i.e. usually vertically), the section being straightened will be constrained to follow a path curved normal to the curvature mentioned above — as in the case of the known straightening machines.

By adjusting the spacing between the constraining and pressure rollers, and their relative positions both parallel to their axes and in a plane normal to the plane containing both their axes, either a part only or the whole of the section being straightened can simultaneously be reduced as it passes through the machine.

Preferably, suitable means are therefore provided to allow adjustment of each roller in two mutually perpendicular directions, one of which is the roller axis itself.

In a preferred straightening machine of this invention, the path along which a section to be straightened is constrained to follow is generally linear (i.e. straight), there being several pairs of constraining and pressure rollers disposed with their axes generally horizontal, the centre lines of the constraining rollers being disposed alternately to either side of the straight line of the path, and the rollers of each pair being displaced vertically with respect to each adjacent pair.

Thus, though the line of the path is gener-

ally straight, the actual path is wavy both horizontally and vertically.

Preferably, the path continues beyond the pairs of constraining and pressure rollers, and extends through further constraining rollers arranged as in known machines with the rollers spaced along the path, adjacent rollers being on opposite sides of the path to define a wavy path therebetween.

By way of example only, a straightening machine constructed in accordance with this invention will now be described, reference being made to the accompanying drawings, in which:—

Figure 1 is a diagrammatic elevational view of a known form of roller straightening machine;

Figure 2 is an end view of the machine of Figure 1;

Figure 3 is a sketch showing the desired state in which a piece of material being straightened makes appropriate contact with a straightening roller;

Figure 4 is a sketch showing the state in which a piece of material has moved away from the straightening roller;

Figure 5(a) is a diagram of an unequal angle (an "invert") to be straightened;

Figure 5(b) shows the angle at which an invert is threaded through the straightening machines to ease the difficulties of straightening inverts horizontally and normal to the rolling direction;

Figure 5(c) is a sketch showing the abnormal deformations often present when the invert of Figure 5(a) has been straightened;

Figure 6 is a diagrammatic elevational view of one arrangement of straightening machine according to this invention;

Figure 7 is a sketch showing the operation of the machine of Figure 6, wherein material is normally held between a constraining roller and a pressure roller;

Figures 8a to d 9, and 10a and b show various views and parts of one embodiment of the roller straightening machine constructed in accordance with this invention, Figures 8c and d respectively being sectional views on lines A—A and B—B on Figure 8a, and Figure 10b is a sectional view on line A—A on Figure 10a.

Figures 1 and 2 diagrammatically show side and end views of a commonly used form of straightening machine. A plurality of upper rollers 2 and lower rollers 2' are disposed as shown, so as to define a wavy or zig-zag path therebetween along which is passed material 1 to be straightened. Pairs of guide rollers A and B are arranged at each end of the path, the guide rollers having their axes vertical and arranged so as to control lateral movement of the material 1, transverse to the rolling direction.

The peripheries of the rollers 2 and 2' are shaped so as to be suitable for engaging the

material to be straightened — as can be seen in Figure 2. Furthermore the rollers are mounted for movement both vertically and parallel to their axes, so as to allow adjustment of the machine.

With a conventional roller straightening machine as described above, sufficient positive and negative bends may be imparted to the material in the vertical direction, so that a satisfactory straightening effect in that direction may be obtained, but the straightening effect in the horizontal direction perpendicular to the direction of advance of the material 1 (i.e. transverse to the rolling direction) is not sufficient, in view of the roller arrangement. For example, when straightening an unequal angle section (referred to herein as an "invert", and shown in Figures 3 and 4), difficulties arise because such a section has a high rigidity horizontally and normal to the direction of advance (i.e. to the left and right in Figure 3). If the rollers are set so as to be displaced along their axes so as to define a zig-zag path horizontally as well as vertically, the material 1 will move away from the defined path by virtue of a force resulting from its rigidity. Thus, the material will tend to shift to the position shown in Figure 4, resulting in an insufficient straightening effect in the horizontal transverse direction.

To help correct this defect, straightening of many steel sections is effected with the section inclined to the roller axes — as shown in Figures 3 and 4. For an invert such as shown in Figure 5(a), a straightening operation is apt to cause abnormal deformations due to buckling, resulting in a final product as shown in Figure 5(c). Furthermore, the threading up of the material 1 through constraining rollers that are arranged to hold the section at an acute angle to the roller axes — such as shown in Figure 5(b) — is difficult, so that working of such sections by the commonly used straightening machine is considerably hindered.

A roller straightening machine constructed in accordance with this invention will now be described, with reference to Figures 6 to 10.

In Figure 6, the material 1 to be straightened is shown passing over constraining rollers 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, suitably disposed to define a zig-zag (i.e. wavy) path for the material 1. Pressure rollers 11¹, 12¹, 13¹, 14¹ and 15¹ are provided opposed to rollers 11 to 15, respectively, to define therewith pairs of rollers. An appropriate number and the spacing of the constraining rollers are selected for the steel section to be straightened — for example 10 constraining rollers can be provided as shown in Figure 6.

As shown in Figure 7, the peripheries of the upper constraining roller 11 and the

lower pressure roller 11¹ are shaped appropriately so as to conform substantially to the shape of the steel section in contact therewith. The constraining rollers are constructed so as to have sufficient strength to allow light rolling of the material in combination with their associated pressure rollers. The peripheries of the other upper rollers 12¹, 13, 14¹, 15, 17 and 19 are formed similarly to roller 11, and the peripheries of the other lower rollers 12, 13¹, 14, 15¹, 16, 18 and 20 are also formed similarly to the roller 11¹. The rollers 11, 11¹, 12, 12¹, 13, 13¹, 14, 14¹, 15 and 15¹ constitute a straightening and rolling portion of the straightening machine, where both straightening and light rolling are effected, while the rollers 16, 17, 18, 19 and 20 constitute a straightening portion where only straightening is effected. The lower pressure rollers are mounted so as to be adjustable with respect to the upper constraining rollers, normal to the path along which the material passes, whereby the amount of reduction in the rolling and straightening portion may be adjusted. The adjustment of the lower pressure rollers conveniently can be effected and controlled by a known reduction screw mechanism or hydraulic cylinder or by other suitable means. The lower pressure rollers are also advantageously adjustable in the direction of their axes, and this can be effected by means of a known screw mechanism or other suitable mechanism.

The upper pressure rollers 12¹ and 14¹ are provided with similar mechanisms as the lower pressure rollers, and thus are capable of being adjusted to control the amount of reduction. Similar mechanisms to those described above may be employed here. The peripheries of the pressure rollers 12¹ and 14¹ are also appropriately shaped so as substantially to conform to the cross-sectional shape of the material, in combination with the peripheries of the lower rollers 12 and 14.

Furthermore, the upper pressure rollers 12¹ and 14¹ — like all the other rollers — have a suitable mechanism to allow them to be displaced adjustably along the direction of their axes, for example, by means of a known screw mechanism or other means.

The operation of the straightening machine described above will now be explained.

The relative positions of the constraining rollers, both in the direction of reduction and along the rolling direction, are set up having regard to the amount of straightening required and the section shape, size and material, to define the zig-zag path.

In this embodiment, the above setting up is effected by displacing the lower rollers, but this need not always be the case, dependent up the machine design.

Next in the straightening and rolling por-

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tion, the clearance between the upper and lower rollers of each pair of rollers is adjusted, having regard to the material section, as shown in Figure 7. In fact, the relative positions in the axial direction of both the constraining rollers and the pressure rollers are simultaneously set up, corresponding to the amount of bend to be straightened transverse to the length of the path, and to the size and shape of the section.

When straightening flanged sections (for example as shown in Figure 7), by adjusting the relative positions of the upper and lower rollers along the length of the machine, it is possible to control the clearance between the upper and lower rollers corresponding to the flange part of the section, so that it is possible lightly to reduce only the flanged part of the section.

In this case, as shown in Figure 7, the flange part (short leg) of the material shown in Figure 5(a) is lightly rolled and its thickness is reduced, but it remains within the required tolerance of size, and thus the material can be straightened without abnormal deformation (wrinkle) occurring in the web part (long leg), as shown in Figure 5(c).

A specific embodiment of roller straightening machine according to the present invention will now be described, referring to Figures 8 to 10.

In Figures 8a to d, constraining rollers 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 are shown, these rollers being adjustably movable in the directions of their axes. The upper rollers 11, 13, 15, 17 and 19 are not movable vertically, while the lower rollers 12, 14, 16, 18 and 20 are suitably mounted to allow vertical movement. 11¹, 12¹, 13¹, 14¹ and 15¹ are pressure rollers and all can move independently vertically as well as horizontally in the direction of their axes. The movements of the rollers in the vertical and axial directions are normally effected by a screw mechanism. However, to give elasticity to the positioning of the pressure rollers, springs are provided at the upper end of their screws, and on the roller axes, to bias the rollers to the required position. In this way, an almost constant compression load or light reduction load can be maintained, even though the thickness of the workpiece may vary.

Positioning of the constraining rollers can be effected conventionally, by rotating the screws associated therewith so as to set each lower roller at the required, predetermined height, and by rotating the screws for adjustment of the rollers axially.

While the main constraining rollers are being positioned all of the pressure rollers are left free.

The positioning of the pressure rollers is effected by inserting a workpiece by rotating the constraining rollers after they have been

set. The rollers are then stopped and the clearance between the constraining rollers and the pressure rollers is adjusted by moving each pressure roller in the vertical and axial directions so as to contact lightly the workpiece. The actual setting of the pressure rollers is checked by measuring the gap between the rollers and the workpiece — for instance by means of a thickness gauge or the like. Once the gap has disappeared, each pressure roller is further urged towards its associated constraining roller so as to impart a pre-load. This can be measured by means of a load cell incorporated in the screw mechanism, or can be decided simply by rotating by a small, predetermined amount of the reduction screw, so as to reduce the roller clearance and thus urge the workpiece into contact with the constraining roller.

Once set, the rollers are rotated to feed out the workpiece used for setting, so that the machine can be used normally.

The manner in which the rollers can be moved in the vertical and axial directions will now be described in detail, referring to the roller 15, referring especially to Figure 9.

The roller 15¹ is supported on a shaft 30¹, rotatably mounted in bearings in a fixed housing 23¹. The end of the shaft 30¹ remote from the roller 15¹ fits within a hollow shaft 25¹, a ball bearing 29¹ being interposed between the interfitting parts of the two shafts. A spring 31¹ serves to bias the shaft 30¹ to the left (in Figure 9), the spring bearing on a suitable shoulder of the hollow shaft 25¹. The outer diameter of the shaft 25¹ is threaded and engaged in a nut 24¹ attached to the housing 23¹, a lock-nut 26¹ being provided to secure the shaft 25¹ against rotation when set at a desired position.

To effect adjustment, the lock-nut 26¹ is released, and the shaft 25¹ rotated by means of a hexagonally-headed bolt 27¹ attached thereto, so as to impart axial movement to the shaft 30¹ supporting the roller. The shaft 30¹ itself is not rotated by virtue of the ball bearing 29¹, the axial movement being imparted to shaft 30¹ by the spring 31¹.

Axial movement can be imparted to the upper roller 15 in a similar manner, like numbered parts (except for the prime) referring to similar parts as just described.

Rollers 11¹, 12¹, 13¹, 14¹ and 15¹ can be moved in addition to the axial direction described above also in the vertical direction. The manner in which this is effected will be described referring to roller 15¹, and to Figures 10a and b.

Shaft 32 is supported by a supporting member S and can be rotated by means of the bolt 32-a so as to rotate a sprocket 33, drivingly connected to sprockets 34 and 35 by means of a chain 36. Sprocket 35 is mounted on a shaft 37, which also carries a worm and pinion gears 38 (see Figure 10-b) 130

contained within two spaced gear-boxes 38-a and 38-a'. The pinions of the gear-boxes are internally threaded and engage on threads provided on two shafts 39 and 39'; rotation of shaft 37 thereby threads shafts 39 and 39' vertically within their housings 39-a and 39-a'. The upper ends of the shafts 39 and 39' carry members 40 and 40', and impart vertical movement to a housing 23, via springs (only one—41—of which is shown). In this way, the roller 15' supported within housing 23' can be moved vertically.

The shaft 32' could also be rotated, sprockets 33', 34' and 35' then being rotated by means of a chain 36' so as to rotate the worm and pinion gears 38 to move the shaft 39 vertically.

Adjustment of the pitch between the rollers can be made by moving the housings supporting the rollers. Elongate slots 45 (Figure 8b) are provided in the housings, and screw-mechanisms 42, 42', 46, 46', 47 and 47' are arranged to effect movement of the housings along the length of the machine bed.

The straightening machine of this invention allows the straightening of steel sections of both symmetrical and unsymmetrical cross-sections. In particular, non-symmetrical sections (such as inverts) can be given excellent straightness without distorting their cross-sections. The machine can also operate with low power-consumption whilst giving most efficient straightening.

WHAT WE CLAIM IS:—

1. A method of straightening a section comprising constraining a section to be straightened to move along a path curved in a substantially horizontal plane (as defined hereinbefore), and rolling at least a part of the section simultaneously to reduce the thickness of that part.

2. A method as claimed in claim 1, wherein the path is generally straight, but is curved alternately to either side of the generally straight line of the path.

3. A method as claimed in claim 2, wherein the path is defined by constraining rollers disposed with their centre lines alternately to one and to the other sides of the generally straight line of the path.

4. A method as claimed in any of the preceding claims, wherein at the same time as constraining the section to follow a curved path in a substantially horizontal plane, the section is also constrained to follow a path curved in a generally vertical plane.

5. A method as claimed in claim 2 and in claim 4, wherein the path curved in a vertical plane is wavy about a generally straight mean, so that the section is repeatedly bent in alternate senses in a plane nor-

mal to the axes of all the rollers as the section is moved along the path.

6. A method as claimed in any of the preceding claims, wherein a section having two distinguishable parts is straightened.

7. A method according to claim 1 and substantially as hereinbefore described, with reference to the accompanying drawings.

8. A roller straightening machine for performing the method of any of claims 1 to 7, comprising means including one constraining roller defining a path curved in a substantially horizontal plane (as defined in claim 1) along which path a section is constrained to move whilst being straightened and at least one pressure roller opposed to the said one constraining roller and on the opposite side of the path to the constraining roller, the peripheries of the constraining and pressure rollers being shaped so as to correspond to the shape of the section to be straightened, the pressure roller being mounted for movement towards and away from the constraining roller such that a section being moved along the path can be reduced in thickness by the rollers and both rollers being movable parallel to their axes to adjust the curvature of the said path.

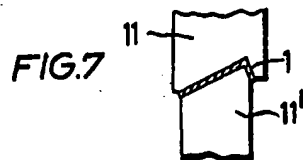
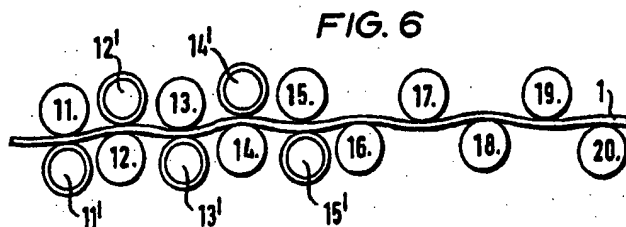
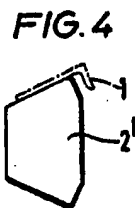
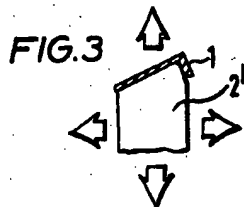
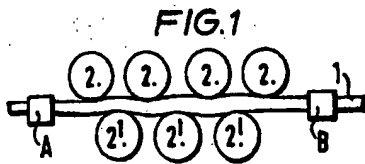
9. A roller straightening machine as claimed in claim 8, wherein suitable means are provided to allow adjustment of each roller in two mutually perpendicular directions, one of which directions is the roller axis itself.

10. A roller straightening machine as claimed in claim 8 or claim 9, wherein the path along which a section to be straightened is constrained to follow is generally linear, there being several pairs of constraining and pressure rollers disposed with their axes generally horizontal, the centre lines of the constraining rollers being disposed alternately to either side of the straight line of the path, and the rollers of each pair being displaced vertically with respect to each adjacent pair.

11. A roller straightening machine as claimed in any of the preceding claims, wherein the path continues beyond the pairs of constraining and pressure rollers, and extends through further constraining rollers arranged with the rollers spaced along the path, adjacent rollers being on opposite sides of the path to define a wavy path therebetween.

12. A roller straightening machine substantially as hereinbefore described with reference to and as illustrated in Figures 6 to 10 of the accompanying drawings.

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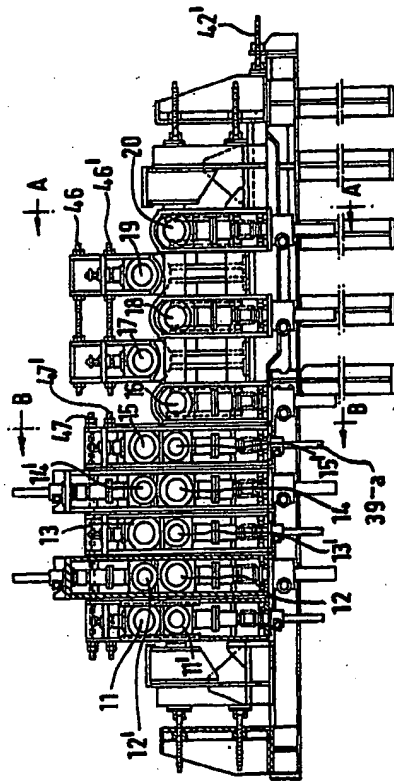
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Sheet 2

FIG. 8a



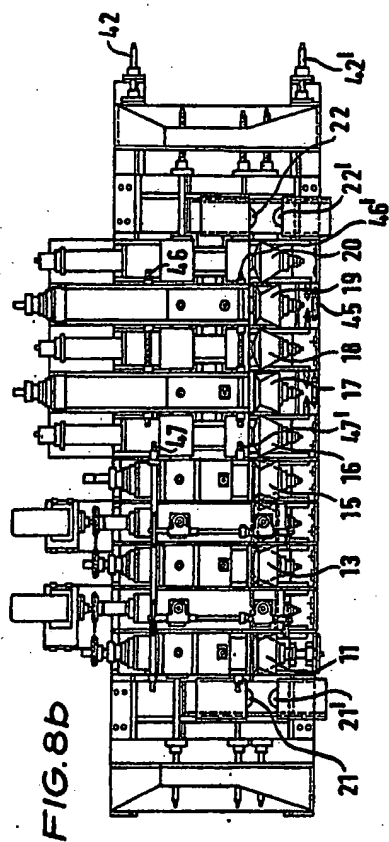
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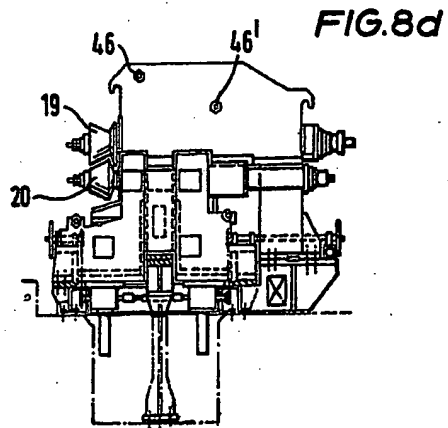
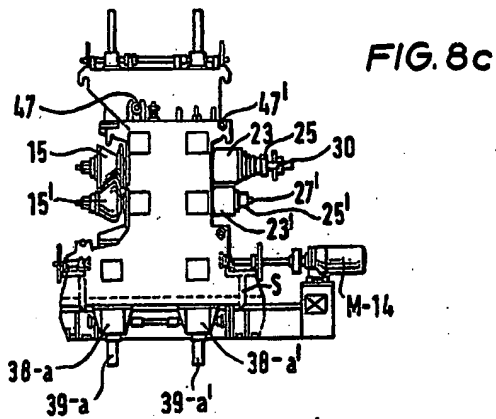
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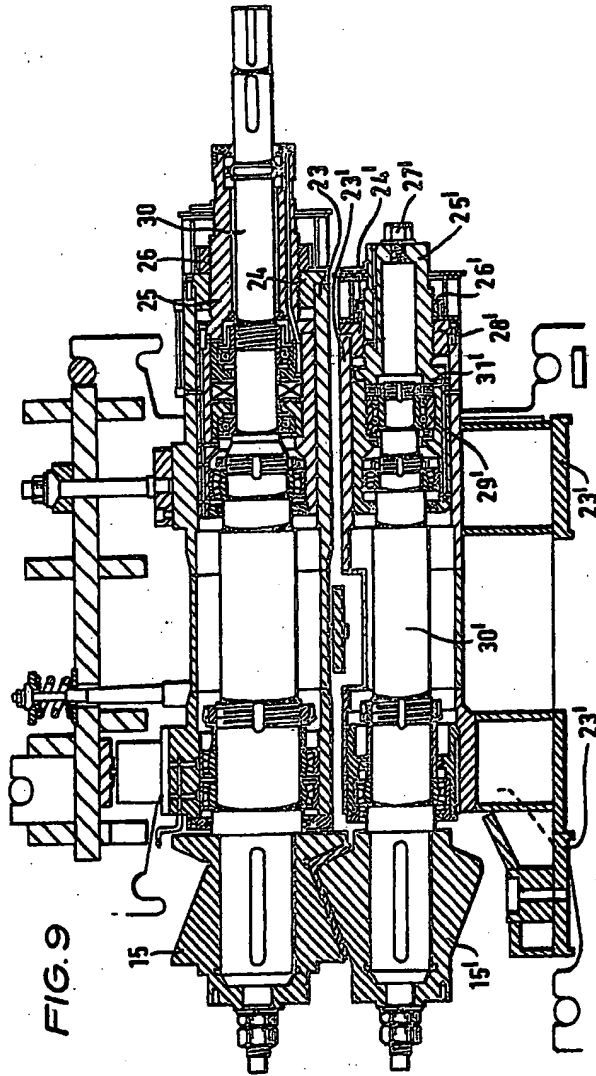


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